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PATENT APPLICATION AF 2822 IFW

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IN THE
UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Janice Nickel

Confirmation No.: 8131

Application No.: 09/981,277

Examiner: M. Lewis

Filing Date: 10/17/2001

Group Art Unit: 2822

Title: SPIN DEPENDENT TUNNELING JUNCTIONS INCLUDING FERROMAGNETIC LAYERS HAVING FLATTENED PEAKS

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TRANSMITTAL OF APPEAL BRIEF

Sir:

Transmitted herewith in **triplicate** is the Appeal Brief in this application with respect to the Notice of Appeal filed on 7/1/2004.

The fee for filing this Appeal Brief is (37 CFR 1.17(c)) $330.00.

(complete (a) or (b) as applicable)

The proceedings herein are for a patent application and the provisions of 37 CFR 1.136(a) apply.

( ) (a) Applicant petitions for an extension of time under 37 CFR 1.136 (fees: 37 CFR 1.17(a)-(d) for the total number of months checked below:

( )	one month	$110.00
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( ) The extension fee has already been filled in this application.

(X) (b) Applicant believes that no extension of time is required. However, this conditional petition is being made to provide for the possibility that applicant has inadvertently overlooked the need for a petition and fee for extension of time.

Please charge to Deposit Account **08-2025** the sum of **$330.00**. At any time during the pendency of this application, please charge any fees required or credit any over payment to Deposit Account 08-2025 pursuant to 37 CFR 1.25. Additionally please charge any fees to Deposit Account 08-2025 under 37 CFR 1.16 through 1.21 inclusive, and any other sections in Title 37 of the Code of Federal Regulations that may regulate fees. A duplicate copy of this sheet is enclosed.

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Typed Name: Hugh P. Gortler

Signature: [signature]

Respectfully submitted,

Janice Nickel

By [signature]

Hugh P. Gortler

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Rev 05/04 (Aplbrief)

Patent
Docket No. 10991744-4

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

APPEAL NO. ________________

In re Application of:
Janice Nickel

Serial No. 09/981,277
Filed: October 17, 2001

For: SPIN DEPENDENT TUNNELING JUNCTIONS INCLUDING FERROMAGNETIC LAYERS HAVING FLATTENED PEAKS

APPELLANT'S BRIEF ON APPEAL

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Assistant Commissioner for Patents Washington, D.C. 20231 on July 2, 2004.

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1. REAL PARTY IN INTEREST

The real party in interest is the assignee, Hewlett-Packard Company.

2. RELATED APPEALS AND INTERFERENCES

Appellant is not aware of any appeals or interferences that would have a bearing on the Board's decision in the pending appeal.

3. STATUS OF CLAIMS

Claims 12-22 are pending in this application. In the final office action dated March 25, 2004, claims 12, 16 and 21-22 were rejected under 35 USC §102(b) as being unpatentable over Gallagher et al. U.S. Patent No. 5,640,343; claims 17-18 were rejected under 35 USC §103(a) as being unpatentable over Gallagher et al. in view of Anthony et al. European Patent No. EP0929110A1; and claims 13-15 and 19-20 were rejected under 35 USC §103(a) as being unpatentable over Gallagher et al. in view of others. Claims 13 and 19 are further rejected under 35 USC §112, second paragraph, as being indefinite.

The rejections of claims 12-22 are being appealed. The pending claims are listed in Appendix A.

4. STATUS OF AMENDMENTS

A response was filed subsequent to the final office action. However, the response was considered non-compliant because the listing of claims did not indicate that claims 1-11 were cancelled. Instead of submitting a set of compliant claims, Appellant filed a Notice of Appeal. Thus the response was never entered.

5. SUMMARY OF THE INVENTION

Magnetic Random Access Memory ("MRAM") is a non-volatile memory that is being considered for data storage in computers. A typical MRAM device includes an array of memory cells. The memory cells include magnetoresistive devices such as spin dependent tunneling ("SDT) junctions.

A typical SDT junction has a pinned ferromagnetic layer, a sense ferromagnetic layer and an insulating tunnel barrier sandwiched between the ferromagnetic layers. The SDT junction exhibits tunneling magnetoresistance ("TMR") in the presence of a magnetic field. Relative orientation and magnitude of spin polarization of the ferromagnetic layers determine the resistance of the SDT junction. Generally, resistance of the SDT junction is a first value R if the ferromagnetic layers have a "parallel" magnetization orientation, and the resistance is increased to a second value R+ΔR if the magnetization orientation is changed from parallel to anti-parallel.

A logic value ('0' or '1') may be written to an SDT junction by setting the magnetization orientation to either parallel or anti-parallel. The logic value stored in the SDT junction may be read by sensing the resistance of the SDT junction.

In an MRAM device including thousands and thousands of SDT junction memory cells, certain SDT junctions will be unusable. They might be unusable because they are shorted, inadvertently loose data during write operations, or don't switch to the desired magnetization orientations during write operations.

Unusable SDT junctions can reduce the storage capacity of MRAM devices, and increase the complexity of read and write operations. Large numbers of unusable SDT junctions result in the rejection of MRAM devices, and consequently, increase fabrication cost.

Appellant addresses these problems. Reference is made to Figure 2, which illustrates a spin dependent tunneling (SDT) junction according to one

aspect of the present invention (see Appendix B). The SDT junction 30 includes a bottom ferromagnetic layer 38, an insulating tunnel barrier 40 atop the bottom ferromagnetic layer, and a top ferromagnetic layer 46 atop the insulating tunnel barrier 40. The bottom ferromagnetic layer 38 has peaks that are flattened (as recited in claims 12-16) or, more generally, peaks that are physically altered (as recited in claims 21-22)

Figure 5 of the application (see Appendix B) illustrates a peak-to-valley height difference before flattening (in dash) and after flattening (in solid). The letter X denotes the height difference between a flattened peak 52 and a valley 54. Flattening the peaks of the bottom ferromagnetic layer 38 has the effect of reducing the peak-to-valley difference in height. Area between grains is also flattened.

With respect to a single SDT junction 30, flattening the peaks of the bottom ferromagnetic layer 38 can be used to reduce or adjust ferromagnetic coupling. With respect to an MRAM device, the flattening provides additional benefits: improving the uniformity of memory cell resistance across the MRAM device; reducing the number of shorted SDT junctions, and allowing insulating tunnel barrier material to be more evenly over the bottom ferromagnetic layers 38, thereby allowing the thickness of the insulating tunnel barriers to be reduced without creating pinholes. Reducing the thickness, in turn, reduces the resistance of the SDT junctions, which can reduce power consumption of the MRAM device.

It has been found that flattening the exposed surface to a critical flatness has been found to significantly reduce or eliminate ferromagnetic coupling. A critical flatness is achieved when the peak-to-valley height difference is ***no more than about one nm***. However, flattening beyond the critical flatness has been found to increase the FM coupling.

Additional reference is made to Figure 1 of the application (see Appendix B), which illustrates an MRAM device according to an embodiment of the present

invention. The MRAM device 8 includes an array 10 of memory cells 12, a plurality of word lines 14 extending along memory cell rows of the array 10, and a plurality of bit lines 16 extending along memory cell columns of the array 10. Each memory cell 12 includes an SDT junction 30, and each SDT junction includes a bottom ferromagnetic layer 38. Each bottom ferromagnetic layer 38 has an upper surface with a valley-to-peak height variation (x) of ***no more than about one nanometer***.

6. <u>THE ISSUES</u>

   a. Whether Gallagher et al. teach or suggests a spin dependent tunneling junction including a bottom ferromagnetic layer with flattened peaks or peaks that are otherwise physically altered.
   b. Whether Gallagher et al. or Anthony et al. teach or suggest a valley-to-peak height variation of no more than about one nanometer on the surface of a ferromagnetic layer of a spin dependent tunneling junction.
   c. Whether claims 13 and 19 are indefinite.

7. <u>GROUPING OF CLAIMS</u>

   Claims 12-16 and 21-22 stand or fall together with respect to issue a.
   Claims 17-20 stand or fall together with respect to issue b.
   Claims 13 and 19 stand or fall together with respect to issue c.

8. ARGUMENTS

I

THE '103 REJECTION OF CLAIMS 12-16 AND 21-22 SHOULD BE WITHDRAWN BECAUSE GALLAGHER ET AL. DO NOT TEACH OR SUGGEST A SPIN DEPENDENT TUNNELING JUNCTION INCLUDING A FERROMAGNETIC LAYER WITH FLATTENED PEAKS OR PEAKS THAT ARE OTHERWISE PHYSICALLY ALTERED

Gallagher et al. disclose a magnetic tunnel junction 8. The magnetic tunnel junction 8 illustrated in Fig. 1B includes a template layer 15, an initial ferromagnetic layer 16, an antiferromagnetic layer 18, a fixed ferromagnetic layer 20, a thin tunneling barrier layer 22, a soft ferromagnetic layer 24, and a contact layer 25. The structure of this magnetic tunnel junction 8 is described on col. 4, lines 16-25, and its fabrication is described in col. 5, lines 49+.

Gallagher et al. do not teach or suggest that the peaks of a ferromagnetic layer are flattened or otherwise physically altered.

The examiner has argued that Gallagher et al. disclose peaks of a bottom ferromagnetic layer that are flattened or otherwise physically altered. The applicant reviewed Gallagher et al. and saw no such teaching. The undersigned viewed the examiner's allegations as unsupported, and challenged the examiner to cite the column and line number of a passage where Gallagher et al. describe flattened peaks. The examiner did not respond to the challenge.

All the examiner relied upon was Fig. 1B, and her opinion that "the formation of the tunneling barrier layer will result in the peaks of the ferromagnetic layer being will result in the bottom layer being 'physically altered,' since the

tunneling barrier is formed on top of the ferromagnetic layer (the examiner's opinion is presented on pages 9-10 of the office action dated March 25, 2004, which is attached as Appendix C). Regarding Fig. 1B, the examiner states "the layer of Gallagher has a valley to peak height variation of zero, which is encompassed in the claimed range of 'no more than about one nanometer.'"

Fig. 1B simply shows a stack of layers. It does not illustrate the surface of any "bottom ferromagnetic layer" in sufficient detail to indicate that peaks are flattened, or that the surface has a zero variation in height.[1]

The documents made of record do not support the examiner's opinion that depositing the tunnel barrier will flatten the peaks of the underlying ferromagnetic layer. Therefore, the record contains no facts that would support a '103 rejection.

In order to establish a prima facie case of obviousness, the examiner must, in the first instance, show that some objective teaching or suggestion in the applied prior art taken as a whole and/or knowledge generally available to one of ordinary skill in this art would have led that person to the claimed invention as a whole, including each and every limitation of the claims, without recourse to the teachings in appellants' disclosure. *See generally, In re Thrift,* 298 F.3d 1357, 1364, 63 USPQ2d 2002, 2006 (Fed. Cir. 2002).

An examiner's unsupported allegations with respect to knowledge in the prior art does not provide substantial evidence of such suggestion or motivation, particularly in light of a challenge thereof by appellants.

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[1] Contrast Fig. 1B of Gallagher et al. to Figure 5 of the present application, which is an illustration of a peak-to-valley height difference on the upper surface of the bottom ferromagnetic layer of an SDT junction.

The examiner has been challenged to provide evidence of flattened peaks in the prior art, but instead only provides unsupported allegations. Prima facie obviousness of claim 12 has not been made. Therefore, claim 12 and its dependent claims 13-16 should be allowable over the current documents of record.

II
'103 REJECTIONS OF CLAIMS 17-20 SHOULD BE WITHDRAWN BECAUSE NEITHER GALLAGHER ET AL. NOR ANTHONY ET AL. TEACH OR SUGGEST A FERROMAGNETIC LAYER OF A SPIN DEPENDENT TUNNELING JUNCTION WITH A VALLEY-TO-PEAK HEIGHT VARIATION OF NO MORE THAN ABOUT ONE NANOMETER

The examiner acknowledges that Gallagher et al. do not teach or suggest such a valley-to-peak height variation. However, the examiner contends that "Anthony discloses the use of ferromagnetic materials with a thickness of no more than about one nanometer.... It would have been obvious ... to modify the semiconductor device of Gallagher to include the use of ferromagnetic materials with a thickness of no more than about one nanometer...."

The examiner's analysis of Anthony doesn't address the issue. The issue is not whether Anthony's interface layer would have a thickness of about one nanometer, but rather whether Anthony's interface layer would have a valley-to-peak height variation of no more than about one nanometer.

None of the documents made of record suggest that Anthony's interface layer, if deposited on Gallagher et al.'s device, would have has a valley-to-peak

height of about one nanometer. The interface layer would be deposited on a pinned ferromagnetic layer. The topography of the interface layer matches the topography of the underlying pinned ferromagnetic layer. Therefore, the interface layer would have the same valley-to-peak height variation as the underlying pinned layer. As the examiner acknowledges, Gallagher et al. do not teach or suggest a surface having a one nanometer peak-to-height variation.

Therefore, the documents made of record do not teach or suggest each bottom ferromagnetic layer having an upper surface with a valley-to-peak height variation of no more than about one nanometer. Accordingly, the '103 rejections of claim 17 and its dependent claims 18-20 should be withdrawn.

The examiner states that the applicants must establish the critical nature of valley to height difference of no more than one nanometer. However, no such requirement exists. MPEP 2144.05 does not require an applicant to establish criticality of a claimed range, but does allow the applicant to use criticality to rebut prima facie obviousness.[2] However, the examiner has yet to make a showing of prima facie obviousness of claim 17.

Moreover, the '103 rejection has been overcome by a Rule 131 Declaration, which was part of a response submitted October 9, 2002. The Rule 131 declaration included an invention disclosure that was prepared by the inventor. The invention disclosure establishes that the device of claim 17 was actually reduced to practice prior to June 3, 1999. The publication date of Anthony (the European patent application) is July 14, 1999.

[2] In fact, the application does establish the criticality of this one nm height difference: it has been found to significantly reduce FM coupling (see p.8, lines 20-24 of the application).

The filing and issue dates of corresponding U.S. Patent No. 6,169,303 are Jan. 6, 1998 and Jan 2, 2001. Therefore, the '303 patent is a '102(e) reference. However, the '303 patent and the present application are commonly owned, therefore, the '303 patent can't be used in a '103 rejection. For this additional reason, prima facie obviousness of claim 17 has not been established.

III

A '112 REJECTION OF CLAIMS 13 AND 19 SHOULD BE WITHDRAWN BECAUSE THE GRAINS AND GRAIN ANGLES ARE RECITED CLEARLY IN THE CLAIMS AND DESCRIBED CLEARLY IN THE SPECIFICATION

The examiner argues that claims 13 and 19 are indefinite because "[i]t is not clear where the angle is formed. Since "grain" lacks antecedence what and/or where are the grains in the structure of the junction or device."

However, both claims 13 and 19 recite "a grain" (as opposed to "the grain"), and the angle (ϴ) and grains are clearly shown in Figure 5 of the application (see Appendix B). Therefore, the applicant provides antecedent basis both in claims 13 and 19 and the specification.

Moreover, claims 13 and 19 both recite "wherein angle <u>from the top of a grain to an intersection with an adjacent grain</u> is between about three and six degrees." Therefore claims 13 and 19 recite where the grain angle is formed.

9. CONCLUSION

The rejections of claims 12-16 and 21-22 should be withdrawn because the documents made of record do not teach or suggest peaks that are flattened or otherwise physically altered. The rejections of claims 17-20 should be withdrawn because the documents made of record do not teach or suggest valley-to-peak height variation of no more than about one nanometer. The '112 rejection should be withdrawn because claims 13 and 19 are clear and definite. Appellant respectfully requests the Honorable Board of Patent Appeals and Interferences to reverse the rejections.

Respectfully submitted,

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Date: July 2, 2004

10. APPENDIX

Appendix A. The Claims on Appeal

The pending claims are as follows:

12. (Original) An SDT junction of a memory cell for an MRAM device, the junction comprising:

a bottom ferromagnetic layer, the bottom ferromagnetic layer having flattened peaks;

an insulating tunnel barrier atop the bottom ferromagnetic layer; and

a top ferromagnetic layer atop the insulating tunnel barrier.

13. (Original) The junction of claim 12, wherein angle from the top of a grain to an intersection with an adjacent grain is between about three and six degrees.

14. (Original) The junction of claim 12, wherein the flattened peaks have a valley-to-peak height difference of no more than about one nanometer.

15. (Original) The junction of claim 12, wherein the junction has a resistance of less than about 10 $K\Omega\text{-}\mu m^2$.

16. (Previously presented) The junction of claim 12, wherein the top and bottom layers are AF coupled; wherein the flattened peaks tune the AF coupling to a desired level.

17. (Previously presented) An MRAM device comprising:

an array of memory cells, each memory cell including an SDT junction, each SDT junction including a bottom ferromagnetic layer, each bottom ferromagnetic layer having an upper surface, each upper surface having a valley-to-peak height variation of no more than about one nanometer;

a plurality of word lines extending along memory cell rows of the array; and

a plurality of bit lines extending along memory cell columns of the array.

18. (Original) The device of claim 17, wherein resistance variation of the junctions across the entire array is no more than about 4%.

19. (Original) The device of claim 17, wherein angle from the top of a grain to an intersection with an adjacent grain is between and three and six degrees.

20. (Original) The device of claim 17, wherein the junctions have a resistance of less than about 10 $K\Omega\text{-}\mu m^2$.

21. (Previously presented) An SDT junction comprising:

a bottom ferromagnetic layer having physically altered peaks;

an insulating tunnel barrier atop the bottom ferromagnetic layer; and

a top ferromagnetic layer atop the insulating tunnel barrier.

22. (Previously presented) The junction of claim 21, wherein the physically altered peaks are flattened peaks.

Appendix B

FIG. 1

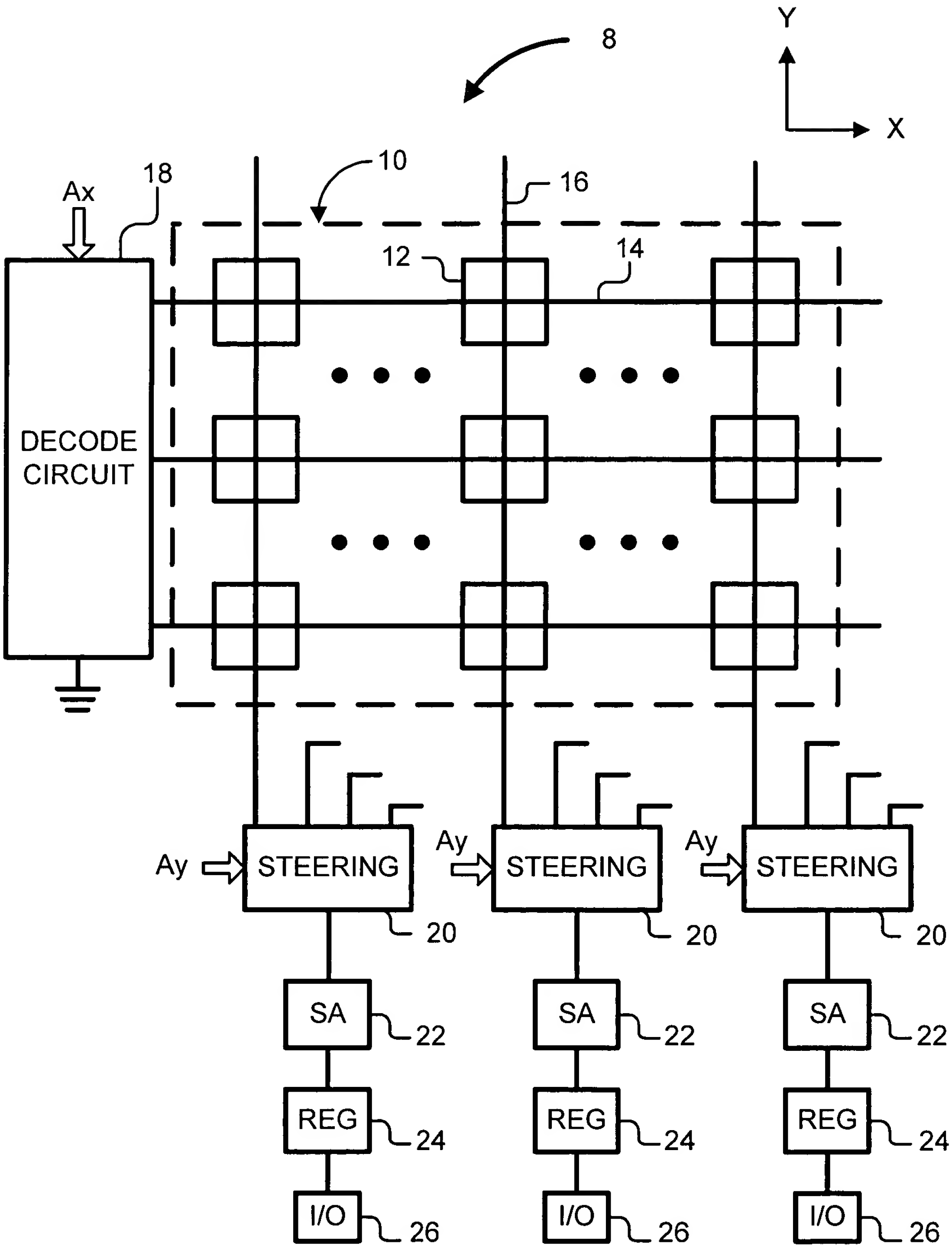
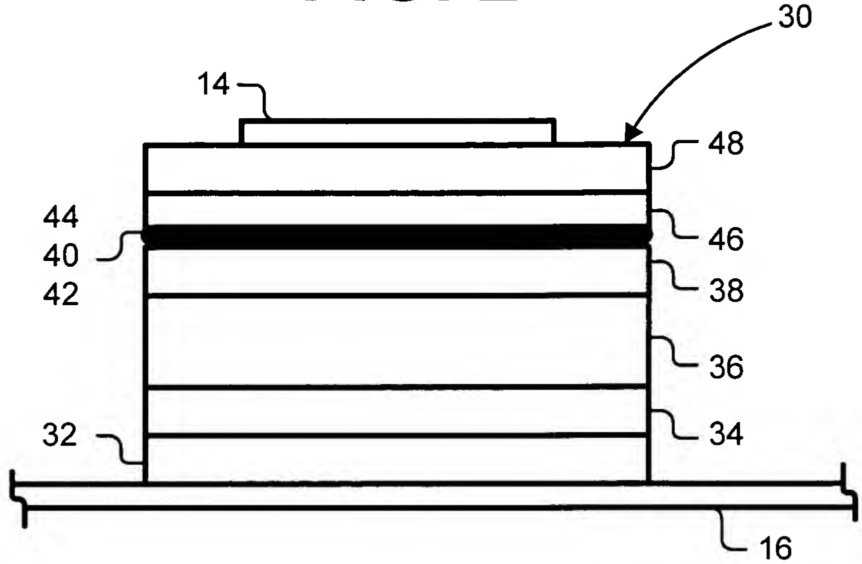


FIG. 2



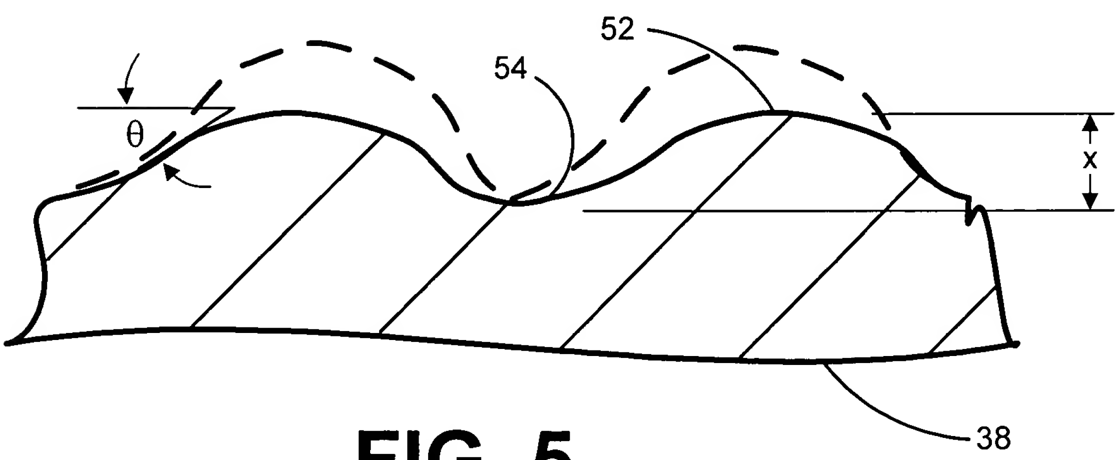


FIG. 5

However, Chen discloses a junction resistance of 10 kohms (For Example: See Column 4 Lines 38-43). It would have been obvious to one having ordinary skill in the art at the time the invention was made to modify the semiconductor device of Gallagher to include a junction resistance of 10 kohms as disclosed in Chen because it aids in providing current to flow through the layer (For Example: See Column 4 Lines 34-43).

Additionally, the applicant has not established the critical nature of the resistance of less than about 10 $K\Omega\text{-}um^2$. "The law is replete with cases in which the difference between the claimed invention and the prior art is some range or other variable within the claims. . . . In such a situation, the applicant must show that the particular range is critical, generally by showing that the claimed range achieves unexpected results relative to the prior art range." *In re Woodruff*, 919 F.2d 1575, 16 USPQ2d 1934 (Fed. Cir.1990).

Finally, since Gallagher and Chen are both from the same field of endeavor, the purpose disclosed by Chen would have been recognized in the pertinent art of Gallagher.

Response to Arguments

14. Applicant's arguments filed 1/2/04 have been fully considered but they are not persuasive. First, Applicant argues that Gallagher et al. ("Gallagher") fails to disclose "a bottom ferromagnetic layer having flattened peaks or peaks that have been otherwise physically altered." However, claim 12 merely requires that the ferromagnetic layer have flattened peaks. Gallagher discloses that the tunneling barrier layer has a planar surface area hence the formation of the tunneling barrier layer on top of the ferromagnetic layer will result in the bottom layer having "flattened peaks" (For Example: See Figure 1b). Since the claim is a product claim, the bottom ferromagnetic layer can be flattened by any method in order to render the claims obvious.

Second, Applicant argues that Gallagher fails to disclose "physically altered peaks." However, the formation of the tunneling barrier layer will result in the peaks of the ferromagnetic layer being "physically altered," since the tunneling barrier layer is formed on top of the ferromagnetic layer. Finally, the structure of Gallagher shown in Figure 2 depicts layers having flat planar surfaces, it is argued that the layer of Gallagher has a valley to peak height variation of zero, which is encompassed in the claimed range of "no more than about one nanometer."

Conclusion

15. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Monica Lewis whose telephone number is 571-272-1838. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Amir Zarabian can be reached on 571-272-1852. The fax phone number for the organization where this application or proceeding is assigned is 703-308-7722 for regular and after final communications. Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

ML

March 18, 2004

Mary Wilczewski
Primary Examiner